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THE AIR LINE PILOT

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Air lines financial picture
An interview with N. Halaby

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On The Cover

UN WE BELIEVE

Cover photo courtesy Western Airlines

This dramatic night scene shows the last moment preparations for the maiden flight of Western Airline's new Boeing 720B on the Boeing Company ramp at Renton, Washington. The 720B fan jet service was inaugurated May 15, 1961, between Los Angeles and Mexico City. The 720B is rated as Mach .9 (615 mph) and is powered by Pratt & Whitney JT3D-1 turbofan engines. Cruising range is 3,700 miles.

A PERSONAL CHECKLIST

You go through a checklist before flying a plane; why not use the same sensible approach to your personal affairs? By going through this checklist, you can tell where you stand in event of illness, disability, etc., and the benefits available.

Cover of ALPA's Disability Program booklet

By OSCAR WILLIAM CLEAL, Jr., *Captain, Pacific Air Lines*

WHEN a pilot's family is confronted by sickness, disability or death, numerous benefits may be available. The air line he flies for, an ALPA program, the State or Federal government, and the service agencies are some of them. It is therefore prudent for a pilot to make a checklist of available benefits. Such a checklist may disclose duplications or deficiencies in a family's welfare program. It is particularly helpful to survivors who must know promptly what benefits are available.

Such a checklist was prepared for pilots of Pacific Air Lines by the Pilot's Retirement Committee. It is presented here as a model for other pilot groups who may be interested in developing a similar one. Although benefits may vary in different locations, this checklist will indicate the categories that should be explored. Note that it contains two main categories: Sickness or Disability and Death.

SICKNESS OR DISABILITY

1. *Sick Leave* (Company)
   Maximum accrued hours. (See your ALPA-Company agreement.)
2. *Mutual Aid* (ALPA)
   Period of coverage—After 60 days—for 12 months.
   Amount of coverage—
   a) Pilot earning less than $600 per month eligible for Class I membership which pays $250 per month.
   b) Pilot earning more than $600 per month is eligible for Class II membership which pays $500 per month.
   c) Pays $1,000 death benefit to widow, Class I or II.
3. *Loss of License* (ALPA) (revised 10-29-59)
   Period and amounts of coverage—
   a) After 14 month waiting period, $500 per month for 46 months (total of $23,000).
   b) At the end of 24 months, you would have received $500 a month for 10 months under the Plan ($5,000). The Capital Sum you could now take would be $16,250.
   c) After 14 month waiting period and 24 months of receiving $500 per month ($5,000), you may elect 36 Months Benefits Certain option which guarantees you or your beneficiaries $470 per month for 36 months—$16,920 + 5,000=$21,920 total benefits.
   d) The above benefits are based on full coverage. Had you elected 50 per cent coverage when paying premiums, your benefits would be one-half those listed above.

   Claim: A disability must be reported to the insurance company within six months from the start of the disability.
4. *Blue Cross* (Company)
   Period of coverage—number of days. Amount of coverage—what is covered and maximum amount for each item.
5. *Major Medical* (Company)
   Period of coverage—
   Amount of coverage—
   Deductable amount—
   Expenses covered—etc.
6. *Life Insurance Weekly Unemployment Compensation Disability Plan* (Company)
   Period of coverage
   Amount of coverage
7. *State Workmen's Compensation Benefits:*
   Medical treatment
   Temporary disability indemnity
   Permanent disability indemnity
   Death benefits
   Claims
   (Compensation benefits are not subject to income tax)
8. *Company-ALPA Pension Plan*
   Permanent disability

   If a pilot fails to pass the periodic FAA physical examination he will be eligible to retire on a disability pension. The date of disability retirement will be treated as though it were his Early Retirement Date and the benefits so determined.
9. *Personal Sickness and Accident Policies*
10. *Personal Life Insurance Policies*
    Check private Insurance Company and GI policies for disability clause.
11. *Social Security*

    Severely disabled workers do not have to wait until they reach 50 years of age to collect disability benefits. Under old law a disabled worker had to be at least 50 years old to collect disability insurance benefits.

NOTE: *Benefits change due to Acts of Congress—check with the nearest Social Security Administration office listed in your phone book under U. S. Government—Department of Health, Education and Welfare.*

12. *Federal Income Tax Deductions on Sick Pay*
    Illness and accidents—

    Pay up to $100 per week while you are out because of injury or sickness may be tax free.

    If you were out sick, your sick pay is tax free only after the first seven days of your absence. But there is no seven day waiting period if you were out because of an injury or if you were hospitalized for at least one day during your illness. (Check Sick Pay section of current copy of J. K. Lassen's, *Your Income Tax.)*
13. *ALPA Credit Union*
    Check Credit Union for savings, loans, etc.

    Remember your ALPA Credit Union stands ready to make loans up to $750 on your signature alone with a maximum repayment period of 24 months. Loans up to $5,000 may be made up to three years maturity on approval of collateral or with co-signers.

IN THE EVENT OF DEATH

14. *Check company personnel department for*
    a) Salary due, vacation due
    b) Retirement funds available
    c) Group insurance policies
    d) Credit Union—insurance to cancel loan or withdrawal of savings account monies
15. *Air Line Pilots Association*
    a) Mutual Aid—$1,000 available upon presentation of death notice by telegram by local LEC to Mutual Aid Association.
    b) ALPA Group Life Insurance—$10,000 original, $20,000 maximum.
    c) Credit Union—Funds available on share account or insurance to cancel if loan outstanding.
16. *Personal Insurance Policies*
17. *Special Lodge — Fraternity* — Cali-

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HUMAN ENGINEERING

Are the human factors overlooked in the design of aircraft? Do aeronautical engineers try to make the man fit the machine rather than the machine fit the man? Drawing upon his years of experience with aircraft, Captain Gunn discusses potential hazards built into the design of some aircraft because engineers did not take into account human factors. He calls for more human engineering to eliminate these hazards.

By CAPT. WALTER H. GUNN,
TWA Council No. 3

This article has been adapted from a speech given by Captain Gunn to the aeronautical engineering students of the University of Kansas, September 19, 1960.

As a preface to this article, let me emphasize that it is written from a *pilot's point of view*. While it may lack the scientific data documentation demanded of an engineer's thesis, it does, however, represent the first-hand observations and experience of a "consumer" of the aeronautical engineers' "products."

The field of human engineering may be viewed as a "functional discipline." It follows that the prime purpose of human engineering is to provide the designers, manufacturers, technologists, and engineers with the information they need *to fit the machine to the man* rather than fitting a man to the machine.

One of the limiting factors in manned flight is man himself. To continue technical advances in aviation today, an inter-disciplinary approach is needed; the physical scientist must call upon the behavioral scientist to assist him in the design of machines which fit man —the "consumer."

When man is related to a machine, a new kind of dynamics enters the physical science field. The sociologist, psychologists, physiologist, and the anthropologist become valuable assistants. This thinking is also basic to our space program—the adaptability of man to the environs of space.

Human Engineering goals

To a pilot the primary goal of any aeronautical project is *safety*. Safety originates in the design. The contribution aeronautical engineers can make to safety is directly proportionate to the degree of "designed safety" the engineers' products possess.

Related to safety is the secondary goal of comfort—or the environment for man. Environmental factors to consider are: spatial facilities—cockpit, work areas, etc.; sensory effects—lighting, ventilation, temperature, pressure, noise, vibration, escape facilities, etc.; and other physiological stress conditions which may have a bearing on the performance of a man.

The consideration of human engineering principles will contribute to design of safe machines for man's use.

Design and "pilot error"

It is the writer's view that operating procedures and techniques are determined by the design characteristics of the aircraft. This premise leads to the determination of "cause" when accidents occur.

Some 60 per cent of all aircraft accidents are relegated to the "pilot error" file. What is the basis of calling a mishap "pilot error"? Visualize a three-sectioned file—two small compartments and one big area. The two smaller sections can be labeled (1) *"physical unfitness"*—physical impairments from a variety of conditions: coronary attacks, fatigue and other disabilities which may occur in flight. (A more suitable term would be "human failure" or "error" rather than "pilot error.") (2) *"Deliberate infraction of operating rules."* (3) The third compartment and the larger one would be placed those accidents attributable to *"inadequacy of information to the pilot."* Thus, the pilot "errors" because of inadequate information supplied to him. Rightfully, the causes of inadequate information should be traced to its source.

Visual information

The most important information for pilots is transmitted through his *visual* senses. This has been the findings of both the military and civil studies on this subject. This is not difficult to accept even though the term "flying blind" is used.

Flying can be conceived of as moving through space and time dimensions. Vision then provides the important "cues" for man's orientation in the air. Six visual "cues" are considered necessary to provide accurate space-time orientation for a pilot[1]. They are:

1. *Internal reference*—that which provides the pilot to regard himself as an integral unit of the aircraft.
2. *External reference*—such as horizon, but not sufficient in itself.
3. *Linear perspective* — simulation of parallel lines for judgment of angle and attitude as well as direction. (For example, runway width or landing level-off.)
4. *Terrain texture*—can supplant horizon by adding surface slant, altitude and distance. (For example, final low approach contact reference.)
5. *Size and shape*—aid in determining distance and relative location
6. *Motion parallax*—distortion of visual field by movement over, giving distance, direction and speed.

Instrument design

To "fly by instruments" those six factors must be taken into consideration

(in the design of instruments—horizons, altimeters, airspeed, gyros, and related "blind flying" instruments.

One must be cautious of advance designs in instruments. An "improved" design requires careful integration with other instruments when it is installed. Also, how the pilot will react to the new instrument.

To illustrate a so-called improved design altimeter of the barrel-type indicator rather than the clock-hand design was recently installed in a new turbo-prop transport aircraft. It required considerable time for a pilot to make the transition from the conventional altimeter to the new. In fact this barrel-type reading altimeter was considered a contributing factor in a fatal accident less than one month after it was placed in service. New instruments and new aircraft are a bad combination. In this accident the pilot misinterpreted the barrel-type altimeter reading during an instrument approach.*

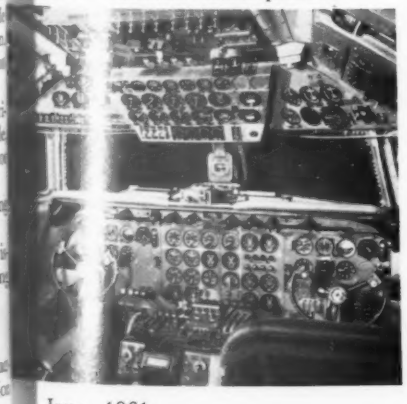
Other design changes have resulted in mis-interpretation of instruments. For example:

1. Old gyro heading to new radio magnetic indicator. (A change from "out-in" to "in-out" concept or from external to internal reference.)

2. Fixed aircraft and movable horizon line to moving aircraft and fixed horizon. (Reversal of "out-in" to "in-out" concept.)

*ALPA does not agree with the writer's analysis of this particular accident. However, ALPA does agree with the writer that at times instruments are designed which are susceptible to misinterpretation by a pilot. (Editor)

Pilot's information inadequate?



3. Change in ILS localizer and glide slope indication from pivoting at top and sides to full travel movement vertically and horizontally.

4. Course reversal designs for use of back-course navigation of OMNI and ILS systems. (Necessitates reverse turns when a back-course approach is being conducted. This has contributed to untold missed approaches and some accidents on record.)

The notable lack of standardization among manufacturers of instruments would cause considerable misinterpretations if a pilot were to "sample" some of the flight instruments on a variety of aircraft.

The latest attempts to eliminate errors in interpretation are the "integrated flight systems." This method incorporates many instruments into one large integrated display of horizon, course flown, course desired, glide slope, full data on pitch, roll, yaw, speed and altitude, and even the aircraft track is depicted on a display grid by means of electronic data computers. One system is called "contact analog" and was developed for all-weather interceptors.

Presently another integrated display system is known as "kinalog system"[2]. Still, dissimilarity exists between the two systems. "Contact analog" represents the external reference technique, while kinalog uses internal reference, allowing more "kinesthetic feel" ("kinalog" is derived from "kinesthetic"). The writer's view is that we should stick with one principle and personally prefers a system based on internal reference.

Errors of interpretation may be minimized through thoughtful design applications of functional displays of data. That is, needles should point "to" desired fix, up or down, right or left, with a consistent reference—internal or external. Any design which incorporates a reversal, such as the back-course dilemma, will continue to create confusion, and further decrements in performance.

Contact vision design

New visual cues come into play for contact flight. Variables which are conducive to confusion:

1. *Restricted vision* — windshield, cockpit lighting, etc.

2. *Inadequate approach and runway lighting.*

3. *Non-standard marking and airport facilities.*

4. *Shortness of runways.*

Modern day air transports have to be flown by looking through a "slot" because of limited windshield vision. None at present allow wide-angle vision in excess of 25 per cent of azimuth. It is deplorable in some aircraft; the Constellation has 17 per cent and Douglas 22 per cent.

Often distortions occur in the windshield where panels are in different positions for structural reasons. When the eyes scan from one panel to another, there are "breaks" in the horizon. Such phenonmena are conducive to vertigo reactions. As speeds increase, such anomalies will be intensified.

Cockpit lighting designs demands consideration of all known human optical requirements. Red lighting facilitates dark adaptation of the eyes by becoming inadequate when brighter light stimuli are encountered on a night approach—landing lights, approach or runway lights.

Where there was once the "black hole" on night approaches, there is now the "blacked out" cockpit if cockpit lighting cannot be balanced to the glare of high intensity approach and runway lights. How difficult would it be to incorporate a photoelectric cell on the nose area to automatically regulate cockpit lighting through the final approach of a brilliantly illuminated landing strip?

Over the years I have pondered over an optical illusion during landings which has yet to be corrected. It involves depth perception for the flare or level-off runways of varying widths.

Runway widths are not standardized: they vary from 75 to 300 feet. The pilot invariably tends toward a *high* level off an a *wide* runway and a bounce or *fly-on* on a *narrow* runway. Need this continue?

I offer a method of standardizing all widths of runways by painting two strips 40 feet apart from the center line of all runways. This elementary fix would provide a *uniform* frame of reference for all runway widths. It would serve the public better with safer landings and heighten the pilot's ego[3].

System and control design

"Murphy's Law" states when a task may be performed in a *right* and a *wrong* way, it will be done both ways. Maintenance engineers are concerned with parts designed symetrically—when there is a top and bottom—it is certain they will be installed up-side-down.

Therefore, is one justified in terming as "accident" that which might reasonably be expected to occur? Where aeronautical design invites a hazardous misuse of controls, there is a statistical probability of such mis-use.

At this point I am indebted to Mr.

Benny Howard for expressing what I consider "classic views" of an aviation great[1]. Mr. Howard has held impressive positions as a pilot, design engineer, and consultant to government and industry —going back some thirty years. His novel manner of expressing solutions to design errors by the use of "shoe laces" and "rubber bands" analogies exemplifies his interests in design safety. He refers to himself as a "crusader—with bumps on his head."

To illustrate how Howard's "shoe-lace-rubber band" analogies could have been applied to three categories of accidents due to design errors:

1. B-29 crashes on take-off due to generator switches off. Gear and oil coolers electrically actuated failed when battery power depleted. By Mr. Howard's techniques of system and control design, the B-29 throttle advanced to take-off power would be "tied" to actuate generators electrically.

2. Carrier aircraft lose power of wave-off due detonation. Landing attempt still in high blower from rapid descent approaches. The carrier aircraft would have "rubber bands" between down gear position and low blowers.

3. Premature retraction of flaps and gear on take-off—all aircraft. Premature gear actuation would result from tying together much like anti-scuttle systems which have been perfected between gear struts and up actuating lever. Flap retraction would not be permitted until safe acceleration is reached thus assuring aircraft "settling" into ground on premature flap retraction.

To Ben Howard, ". . . accident prevention involves simple reduction of statistical probability of hazardous misuse of control." To-wit: misuse of gear occurs one each 4,000 landings; misuse of flaps, likewise. Tied together the statistical probability is reduced to once each 8,000 landings as the *lowest* probability—optimum probability could reach 1:160,000,000 miles.

The need to question the need of such design complicity arises when the "check list" technique is considered. By similar logic, one may consider it unnecessary to put doors on elevator shafts; merely place a sign reminding all people to wait until the elevator comes, before stepping in. (Few would doubt the necessity of cleaning out the elevator shaft nightly!) This is not to deny the need nor propriety of a "check list"; rather, we must question the assumption that a check list can be a panacea for eliminating such accidents.

Statistical analysis which show "check list" items that continue to contribute to accidents, indicates a reluctance to modify or redesign the offending element. An example which supports this statement is: the gear-flap group, attempted take-off in DC-4s, and other gust-lock designed aircraft, with gust lock engaged. The latest of these accidents claimed the lives of some 90 servicemen on a late-designed transport for troop carrying.

Add to this list of things which comprises flight safety today, design errors which permit improper installation, maintenance or service of equipment.

This emphasis on control and systems designs is not meant to detract from the urgency of designing for safety in other areas of aviation.

"It's no use, Finchly. Daddy won't allow me to go out with an air line man!"

Comfort factors of design

Great concern for man's comfort is prevalent in the "Man in Space" research program. This same concern for pilot comfort in conventional aircraft is less apparent. As an example I submit the DC-4. A diligent search has yet to reveal any one person properly proportioned who could be comfortably seated and be within reach of all controls. One eloquent associate I know, described the necessary attributes for DC-4 pilots as having " . . . one long arm and one strong arm."

That the cockpit design of a DC-4 lacks consideration of human engineering principles I submit:

1. Rudder pedals raised off the floor; it would increase leg muscle fatigue if prolonged rudder pressure is required.

2. Control column too high for low seat adjustment—poor leverage angles.

3. Cockpit seat back too low, does not adjust; arm rests too low (to support elbows requires tilt alignment of spine; seat angle too flat (tendency to slide forward); and short on support of upper thigh area to knees. In all, an inconceivable design for a long-range transport aircraft.

4. Overhead control panel-switches, feather buttons, etc., are only accessible by lifting from one's seated position.

5. Pedestal-prop controls require mispositioning from seat to actuate. Fuel cross-feed valves less accessible. Gear and flap levers invite misuse by proximity and similarity of actuation.

Paradoxically, this aircraft which possesses a multide of fatigue, strain, and discomfort factors, has compiled millions of miles in transport service. Perhaps the discomfort factors are offset by the plane's inherent aerodynamic stability. But one cannot help but wonder why such good design terminated in the cockpit.

Man's limitations

Where a man must make an interpretation before making a response, his reaction time, even if he is at peak physiological proficiency, must be measured in seconds. However, electronic decisions are measured in thousandths of a second.

Extend this premise to the area of optimum technique for take-off performance. Acceleration to rotation velocity if determined by sweep second hand and runway markers (an accepted procedure) is like sawing wood by hand in this modern age. Electronic devices of the most elementary level are available to provide accurate fractional timing of such accelerations to indicate

(Continued on Page 22)

ALONG THE LINE

American Airlines picks captain for traffic study

American Airlines has selected one of its top experts in air traffic control to head a new company effort aimed at the promotion of more efficient use of air space.

Capt. Samuel P. (Sam) Saint, nationally known for his contributions to air traffic control, will become director of air traffic control procedures for the air line. He will work closely with industry and government agencies to make possible even safer and more efficient air line operations of the future, according to an announcement by G. Marion Sadler, vice-president and general manager of American. Mr. Sadler said he hoped other air lines would join American in expanding their efforts toward more expeditious movement of aircraft.

Capt. Saint, who started flying in 1929 and has most recently commanded American's 707 Astrojets, has not only represented American in air traffic control efforts, but also the Air Line Pilots Association, the Air Transport Association and the Federal Government.

Mr. Sadler noted that it was of vital concern to the air line industry to put its best efforts into increasing the rate of flow of aircraft in and out of airports and to make more efficient use of air space along the airways. To help further this end, American has already installed distance measuring equipment (DME) in all its jets, becoming the first air line to do so, Mr. Sadler added.

Capt. Saint has written more than 50 major articles and technical papers on air traffic control for trade journals or engineering technical societies. He designed the first successful approach interval computer for air traffic control in 19[illegible] and coordinated installation and use of this device at La Guardia Field by the Civil Aeronautics Administration, predecessor of FAA.

Capt. Saint, who joined American in 19[illegible] was loaned by the company from [illegible]49 to 1954 to the Air Transport Association to direct its Navigation and Air Traffic Control Division. After serving as consultant to the director of the Air Navigation Development Board in 1955, he returned to flight duty with American in 1956.

Capt. Saint was an early sponsor of direct pilot-to-controller communications, introduced the so-called "twin trombone feed" to approach control in 1946 and drafted the principles for use of radar in air traffic control that were adopted by the Air Coordinating Committee in 1950.

He was born August 3, 1911, in Wyncote, Pennsylvania. He lives with his wife and three children in Wykoff, New Jersey.

Pilot finds some quotable quotes for p.a. system

Nothing to say when you talk to your passengers on the p.a. system? Captain R. E. Bittner of Trenton, New Jersey, a pilot on the now merged Capital Airlines, perks up his remarks with quotes from the tags on Salada tea bags!

(Quite naturally Captain Bittner's activities came to the attention of Salada Tea and he was mentioned in one of their press releases.

Some of the pithy remarks on the tags (written by an advertising man and air force reserve officer by the way) are: Time tells on a man, especially a good time; If you can't write it and sign it, don't say it; Marriage is like a tourniquet—it stops your circulation; He who laughs, lasts; (and an inspirational prod) Plan for the future. That's where you'll spend the rest of your life.)

Allegheny copilot victim of leukemia

D. W. Lang, Jr.

Lt. Donald W. Lang, Jr., a copilot for Allegheny Airlines and an ALPA member, passed away May 30, 1961, of brain hemorrhage brought about by leukemia. He was buried in Pocomoke City, Maryland, his home town.

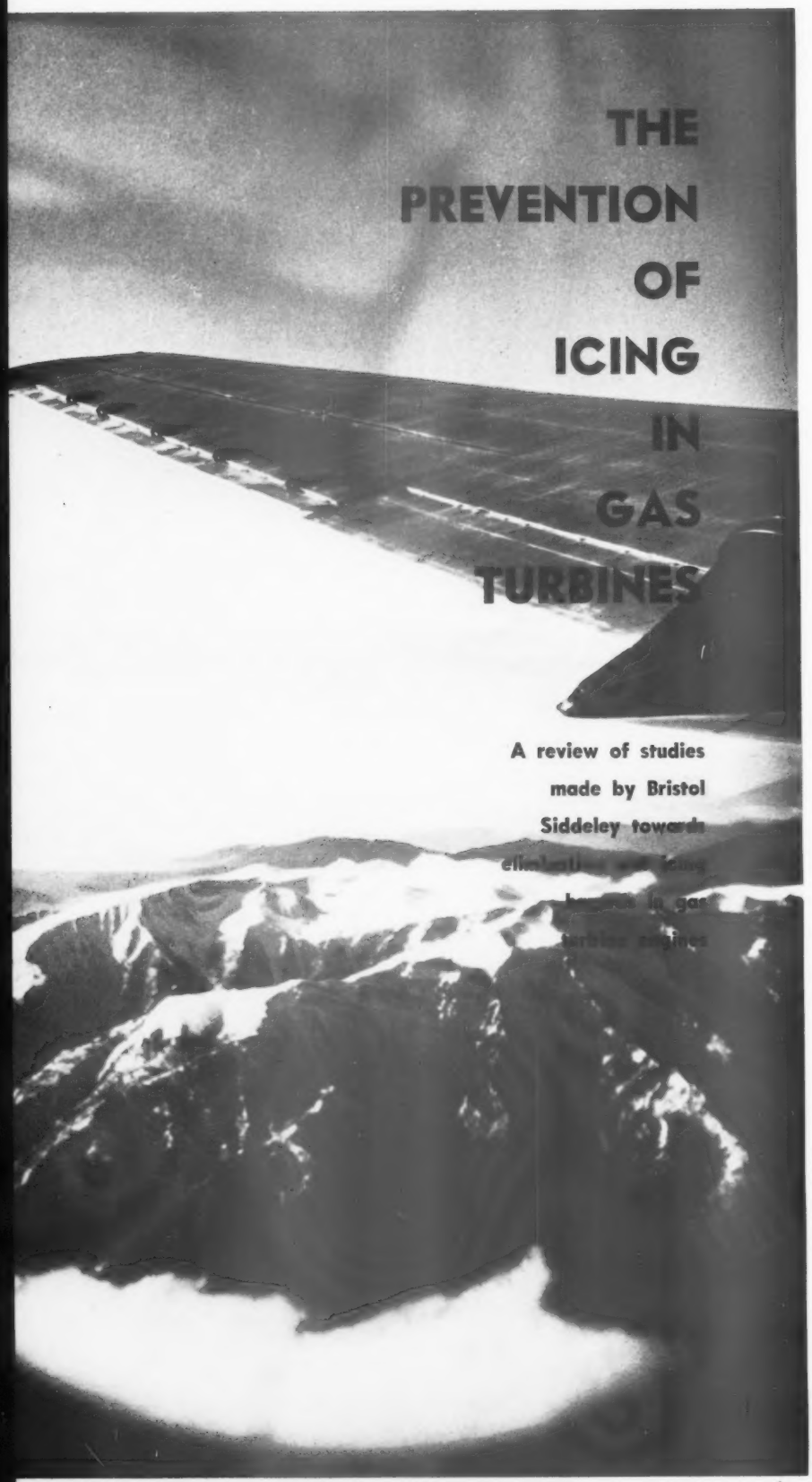
Lt. Lang served with MATS for four year and was copilot for Allegheny for thirteen months. He was 26 years of age. He is survived by his parents and a brother and sister.

NAL captain flies pioneer southern trans-cont. route

Captain C. H. Ruby piloted the proving run of the new National Airlines southern trancontinental route on May 29, 1961. The proving run, an FAA requirement, was a non-stop flight from Florida to California.

A planeload of FAA officers and NAL officials made the flight from Miami to San Francisco, Los Angeles, and San Diego, to check the route, cockpit procedures, air communications, and ground and maintenance facilities.

CAPT. HARRY SUSEMIHL takes a break while picketing at the Atlanta airport with his dog "Jigs." The strike became one year old on June 5, 1961. Captain Susemihl and 138 other pilots are on strike against Southern Airways. They will stay on strike until the company returns their pre-strike seniority status. All the original issues of the year-long strike, which has been riddled with federal agency and court hearings, were settled last July, when the company broke off negotiations.



THE PREVENTION OF ICING IN GAS TURBINES

A review of studies made by Bristol Siddeley towards eliminating [illegible] hazards in gas turbine engines

WET ICING is, potentially, one of the most serious hazards to flying; it affects the aerodynamics and therefore the flying characteristics of aircraft and can cause loss of power or even serious damage to aero-engine. In recent years the problem has become magnified because civil airliners, as well as military aircraft, now operate with gas turbine engines and these are more prone to icing problems than were their piston-engined predecessors.

Ice can build up on any forward facing surface of an aircraft's structure, such as engine air-intakes, intake support vanes and entry guide blades, and is formed by the impact of supercooled water droplets on these surfaces. Such droplets occur in certain low ambient temperature cloud formations and, due to their low local momentum, do not flow with the airstream around the surface, but remain undeflected. The build-up of ice can be extremely rapid, the rate depending on the temperature of the air, the concentration of free water and the size of the droplets.

In addition to wet ice, a more insidious form of icing can occur which is caused by encounters with clouds formed from particles of dry ice. Discussion of its particular effects and its causes is, however, outside the scope of this present article.

In aero-engines the effect of wet ice is to reduce the air intake area with subsequent loss of power; the deformation of aerofoil shapes can cause compressor stall and, under particularly severe conditions, large ice particles may break away to be ingested by the compressor. The resultant damage could cause complete engine failure.

The original proposed solution to the icing problem for gas turbines was a relatively simple measure based on previous piston engine experience.

Tested on the early Bristol Siddeley Theseus engines, it relied upon fitting a grid over the air intake cowl lip. When the grid became blocked by ice the engine suction was so powerful that it drew air into the space between the cowling and the engine through a ring of spring-loaded traps situated towards the rear of the nacelle. This air trav-

Re-printed by permission from the *Bristol Siddeley Journal*, Winter, 1960-61, published by Bristol Siddeley Engines Limited, London.

Bristol Siddeley Photos

elled forward to the intake through the space between the cowling and the engine, and so gained heat. This scheme, however, proved unacceptable because of the reduction in effective intake area and the loss of ram effect.

In the 12 years that have elapsed since the first experiments at Bristol Siddeley, a tremendous amount of work has been carried out and, in common with all other engine problems, the final answer has been obtained only after the painstaking development of the best compromise between theoretical and practical design features.

Design compromise

The compromise took into account three conflicting factors. Firstly, the system employed had to be absolutely effective and leave no margin for doubt; secondly, to satisfy the engine performance engineers it should entail the minimum fuel and thrust penalty; and finally, it had to weigh as little as possible. To design a system in accordance with the first of these demands is difficult enough, without the added complication of the latter two.

An obvious suggestion was to heat the intake air to a temperature greater than 0°C by using gas tapped from the engine exhaust. With air at a temperature as low as—40°C, it needs little calculation to show that the heat required to do this effectively is enormous, even ignoring the latent heat of the water particles and evaporation losses. The idea never progressed to the stage of practical experiment, as although it would undoubtedly work, the system would have incurred a heavy weight penalty and a thrust loss of 30 per cent.

Tests with silicone paints and other low-friction coatings showed no decrease in the amount of ice formation, although it was found that the shear stress of ice on polytetrafluorethylene is only one-seventh of the value of ice on an anodised aluminum surface. This, unfortunately, was still a high enough value for large pieces to build up before aerodynamic forces loosened them.

Low-friction coatings might in future find some use on compressor rotor blades but at present all are subject to considerable erosion under normal operating conditions. From many points of view the best coating is polytetrafluorethylene but it is highly toxic when burned and, therefore, unacceptable because of the risk of contaminating the cabin air bleed.

Investigations have also been carried out into the possible use of certain pastes and jellies intended to depress the freezing point of water or reduce the adhesion of ice. These, although probably quite effective for certain applications, were not found to be suitable on Bristol Siddeley's aero-engines. Some are unsuitable due to their additives having an adverse effect on the engine by gumming or collecting dirt, while others are corrosive.

In general, all these experiments showed that although ice adhesion is lessened, it is not reduced sufficiently for the air forces to dislodge concentrations before they reach dangerous proportions. Moreover, as the ice breaks away there is a tendency for most of the paste or jelly to disappear into the engine with it.

As an extension of the trials with paste and jelly, alcohol fluids sprayed over the areas susceptible to icing were also tested. These compounds are well known for their anti-icing properties and are very active ice removers. Unfortunately, however, there are a number of unacceptable penalties in their use on civil airliners, but for certain military applications they might possibly be justified.

On civil aircraft the primary objection would, again, be the possibility of contamination of the cabin air supply if this air was tapped from the engine compressor. It would also be necessary to carry a very large quantity of alcohol in anticipation of an encounter with ice. Tests on Bristol Siddeley Theseus engines showed that approximately 25 gallons of alcohol would be required every hour flown, for each engine, to keep them free of ice. Obviously, correspondingly larger amounts would be required for larger engines.

Other tests with alcohol fluids at Bristol Siddeley and at the National Aeronautical Establishment in Ottawa showed that unless some form of rotating distributor were used the consumption of the fluid would be doubled. Thus, a mechanical complication is involved.

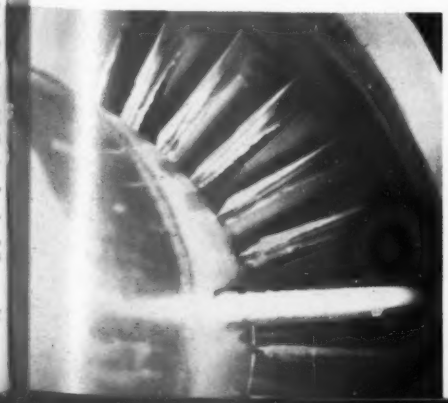
Furthermore, alcohol is unpopular with air line operators as it not only presents customs difficulties but is yet another consumable store to be held in stock.

Heating is solution

Having examined all these schemes it appeared that the only really practical solution would have to rely upon some form of heating, either by oil, electricity or hot gases, and a systematic appraisal of a number of heating schemes was initiated.

All engines have a lubrication system which collects a considerable amount of heat. An attempt was made, therefore, to put this waste heat to use in an ice prevention circuit, but as the heat output is difficult to control and the small anti-icing passages were likely to core when the temperature reduced the viscosity of the oil, the scheme was abandoned. Oil is, in any case, a dirty fluid if spilt and toxic when burned, and this would lead to contamination of the compressor air if any oil escaped.

Two electrical heating schemes were



THESE ILLUSTRATIONS, both taken after five minutes' running in moderately severe icing conditions, show that a continuous methanol spray did not effectively prevent ice formation.

BRISTOL SIDDELEY'S Ashton flying test-bed, fitted with a water spray rig, is used to test anti-icing systems in flight.

examined. The first employed the eddy-current principle whereby compressor blades would be permanently magnetised, or run in a coil-induced magnetic field. The eddy currents produced by breaking the field between the rotor and stator blades would then heat the blades. This system is excellent in theory, but suffers from a weight penalty and offers only a low heating intensity.

A far more practical electrical heating system is resistance heating which relies on mats bonded to the surfaces prone to icing. One major drawback to resistance heating is the size of generator required to supply the power. Heating mats, too, are liable to burning and erosion although by development this situation has been considerably improved.

A recent suggestion, upon which again little work has been done, is oil friction heating. This consists, basically, of a network of capillary tubes through which oil is pumped. The pumping horsepower is dissipated as skin friction loss and consequently heat. This scheme, although undoubtedly heavy, will provide a high heating intensity which cannot be obtained by any other method. Its weight will probably be acceptable for certain specialized cases, for example, a sharp leading edge.

Air or gas heating

Without a doubt the most convenient and most practical form of reducing engine icing is by air or gas heating. The other schemes, although in the main ultimately proving abortive, did provide very valuable experience with which to approach subsequent projects.

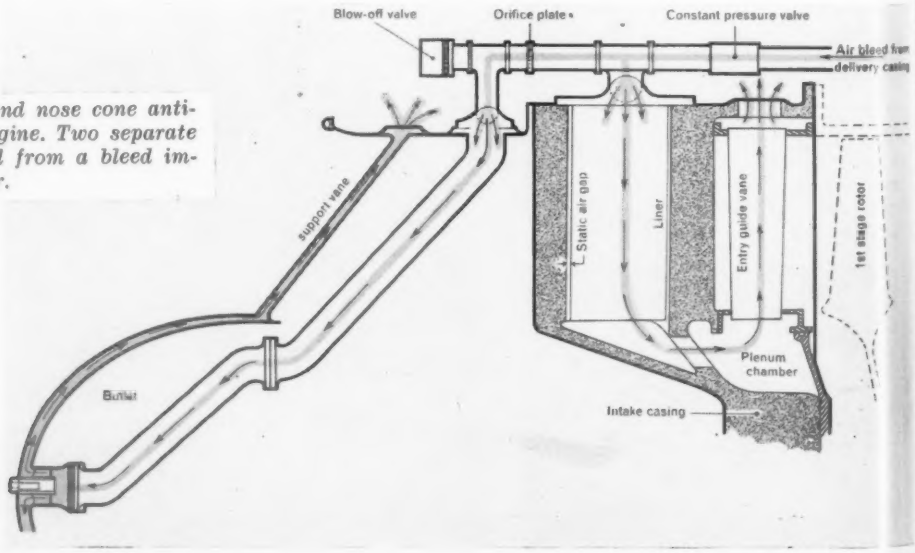
Several years of rig testing, both on the ground and in flight, with icing tunnels and complete engines, have resulted in the development of the present lightweight and highly efficient systems; but even now, the behaviour of ice cannot be wholly predicted and all new engines require invidual investigations to determine the most suitable system. Full-scale tests take place in Canada during winter and in aircraft fitted with water spray rigs. The results obtained, backed by many millions of engine hours in service, have shown that the use of air tapped from the high-pressure end of the compressor is the most simple, lightest and most economic way of providing heat to reduce ice formation.

Heat transfer problems

Entry guide blades, intake bullets and support vanes, compressor rotor blades and engine cowlings all present different problems in heat transfer due, not only to differing shapes, but also to the heat intensity required.

Entry guide blades incorporated in Bristol Siddeley engines vary enormously in size. In the Mamba turboprop, for example, the guide blades are so small that air circulation inside them is impossible. In this case electrical resistance heating was found to be the only practical solution and the method adopted used the blades as resistance elements wired in series on a low voltage circuit. This scheme cleared its trials very successfully, and has now been in production for a number of years.

With the larger Bristol Siddeley engines the blades are big enough to per-



THE ENTRY GUIDE VANE and nose cone anti-icing system on an Orpheus engine. Two separate circuits are employed, both fed from a bleed immediately aft of the compressor.

mit circulation. The larger blades in particular are constructed with internal splines for structural stiffening. The channels formed by the stiffeners permit an efficient heat transfer circuit and allow air to pass along the blade possibly more than once. Such a system can, of course, only be used where sufficiently high temperatures and pressures are available from the compressor.

Difficulties arise where large taper, low thickness/chord ratio blades are concerned. Here, the large chord tip requires a large air flow to keep it clear of ice, but the narrow root chord restricts the flow. These difficulties can be overcome, in part, by fitting a tapered central insert inside the blade, but this does not entirely overcome the icing problem. A more satisfactory arrangement involves using the central spline as the main channel and exhausting the air along the leading and trailing edge cavities to discharge into the compressor at the root and tip.

The air intake bullet and its supporting vanes are also subject to severe icing and require protection to prevent ice growth causing flow disturbances in the compressor and perhaps damage if large pieces of ice were shed.

Two alternative sources may be used to supply the required temperature rise. The vanes and bullet may be linked in series to the entry guide blades and use the air exhausted from them, or a further bleed may be made from the compressor. When it is realized that two bleeds may take up to 5 per cent of the total engine air flow, it can be appreciated that a link with the entry guide vanes is to be desired. The choice of the latter system depends on the relative size of the bullet and vanes to the entry guide blade ring, and the required temperature drop must also be taken into account. Consistent with these considerations, series heating is used on Bristol Siddeley engines wherever possible because it is the most economical. As an example of the two systems, all Olympus engines are fitted with a series arrangement whereas Orpheus engines have two individual bleeds from the compressor.

Compressor icing

Compressor rotor blades may or may not require an anti-icing system depending on the results of engine icing tests. As a rotor blade will always tend to shed ice by centrifugal action, the decision to assist this with heating depends upon the size of the ice concentration formed before shedding takes place. If tests show that the ice fragments do not upset the compressor then heating will not be necessary. Fortunately no Bristol Siddeley compressor has been sensitive enough to be affected by ice shed by the rotor blades and the question of providing heated blades has never arisen.

However, with the introduction of ducted fans which have very large first-stage compressor rotor blades running at comparatively low speeds, the centrifugal forces will be low. This means that large pieces of ice may build up before being shed and, while it is not anticipated that this will cause commustion instability, the unbalance due to unshed ice may be a source of vibration.

To combat this possibility, various schemes are under consideration which propose to augment the low centrifugal forces by a small amount of heating if this is found to be necessary.

Air-intake icing

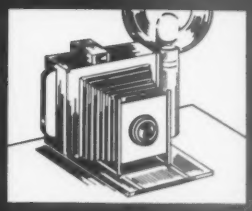
The lip and tunnel leading to the engine air-intake in all aircraft installations, although not strictly part of the engine, is liable to severe icing. The easiest way to prevent this is by ducting compressor bleed air to the cowl lip, passing around the leading edge through a gradually tapering duct and then along the intake duct walls before, finally, discharging it back into the engine or overboard. The tapering duct is necessary to maintain approximately constant heat transfer coefficients to compensate for the temperature fall as the air cools.

Mixed exhaust gas and air could be similarly used, but the outlet would, of necessity, discharge overboard to prevent contamination. There is much to commend this system from a point of view of economy, but some of the equipment involved would be heavy owing to the need for steel and Nimonic ducts to carry the high-temperature exhaust gas. The additional ducting and the need for a temperature control in the system would also be a drawback.

A compressor bleed is not always suitable or available for heating purposes for a number of reasons. It may be that the engine is a simple unit with

(Continued on Page 23)

FLIGHT TESTING, in natural or in simulated icing conditions, plays an important part in the development of anti-icing systems for aero-engines.



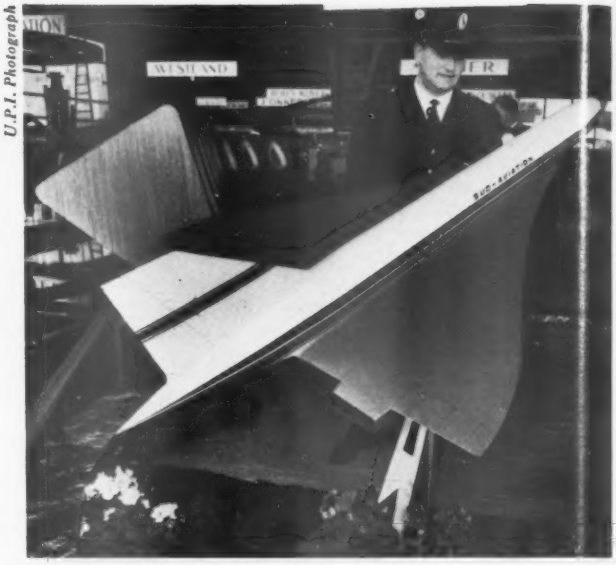
The ALPA Camera

Some Highlights and Sidelights of the News and ALPA in Pictures

Continental Airlines Photo

CONTINENTAL AIRLINES has ordered four Boeing 720B fan-jets for delivery to the company's fleet next spring in time to permit a substantial expansion of jet schedules for the summer vacation months. Planes will carry 108 passengers.

U.P.I. Photograph



SUPER CARAVELLE will be available in 1967 according to Sud Aviation. The mach 2.3 aircraft will be capable of trancontinental flight in the U.S.A. and another model will fly across oceans. There will be four engines in delta wing. Model was displayed in a Paris air show.

U.P.I. Photograph

ROMAN RUINS: A storm of criticism hit airport officials when two of the concrete runways at Rome's Leonardi da Vinci airport began crumbling. The new airport which opened February 1961, was built at a cost of $50 million.

MERGED LOOK; First Viscount, newly-painted with United Air Lines colors leaves its hangar at Washington, D. C. Forty-one Viscounts—mainstays of the Capital Airlines fleet before recent merger of the two companies—will be repainted as they undergo regular overhauls.

United Air Line Photo

Secretary of Labor Arthur J. Goldberg's views were put on the record of the Senate Committee on Labor and Public Welfare at a hearing on his nomination. The following is excerpted from Goldberg's opening statement and replies to questions by members of the committee.

THE VIEWS OF ARTHUR J. GOLDBERG

It is difficult, in all candor, for a person who has been associated as I have been for 23 years representing the labor movement to come here and say that at the moment I have brainwashed myself and have departed from all of the views and convictions which I had throughout the years. It would not be honest if I said that to you.

I enter this post with the firm resolve to serve the public interest in as objective a manner as any human being can do that.

I have completely parted with all of my connections with the labor movement. I do not intend to return, although there is nothing dishonorable in returning, after a period of government service.

The welfare of all

The labor scene is a sensitive scene and I have felt because of its nature the public is entitled to assurance from me that I would act in its best interests.

I hope to do so within the best of my ability and to give the most objective advice that I can give to the President and the most objective leadership that I can give to the Labor Department within the confines of human failings.

Our society is not a class society and the Department of Labor is not and should not be a class department.

The Department of Labor is charged by statute with the responsibility of promoting the welfare of the wage earners of the United States. As secretary, I will attempt fully to implement that policy. But in so doing I do not believe the Department should be regarded as the representative of any special interest group, but as a department representing all sections and interests in our society.

It is my firm belief that although each department of government necessarily must place special emphasis on the sphere of activity with which it is concerned it must, within that sphere, speak for and promote the welfare of all Americans and not any special group or class.

Too much apathy

Congress has given to the Secretary of Labor the responsibility of administration and enforcement of various laws. These include not only the Fair Labor Standards Act, the Walsh-Healey Act, the Davis-Bacon Act and others, but also the Labor-Management Reporting and Disclosure Act of 1959.

I shall do everything in my power to enforce these laws vigorously, fairly, and without fear or favor, and in the spirit of humanity and common sense which I believe should characterize all law enforcement.

I have felt and I still feel that it is a good thing for the country and for an individual to belong to a union. I have felt and still feel that many people who complain against the conduct of unions ought to get into unions and exercise their democratic rights to reform the abuses about which they complain.

I have felt and still feel that one of the disadvantages of our society in the field of unionism, and it percolates through our churches and other organizations, is the apathy on the part of people. An apathetic membership that does not exercise its rights in our political society is more responsible for abuses than anything else.

It is my conviction, and I will feel free to state that conviction, that the right to strike should be exercised sparingly because it is a right which has to be exercised responsibly. It is nevertheless an important ingredient in a free society.

I agree entirely with President Eisenhower when he said some years ago that there are worse things than the right to strike and one of the worst things is the loss of freedom.

In totalitarian countries the right to strike does not exist. The hallmark of a free society as against a totalitarian society—such as what they have in Russia, what they had in Germany—is the right to strike. This right is prohibited in those countries, here we enjoy the right to strike.

Re-examination of problems

The Wagner Act played a most salutary role in promoting the welfare of the wage earners of the United States and in helping to develop ways of industrial peace and promoting our domestic prosperity.

I think now we must take a new look at our problems in this area.

The new look must be in the light of all of the developments that have occurred in the congressional field and

(Continued on the Following Page)

U.P.I. Photograph

The Secretary of Labor, Arthur J. Goldberg

in the industrial field. But I would hope that we could again come to the point of view where the government does not impose restrictions upon the area of collective bargaining within the role of proper government policy.

Under the Taft-Hartley Act, the union shop was recognized to be a desirable goal of government if freely negotiated between labor and management.

I would oppose government imposition of the closed shop or the union shop on American industry.

What I would favor is freedom between labor and management to negotiate appropriate forms of union security in particular industries and even in particular companies.

I would be in favor of allowing, by law, management and labor in collective bargaining to establish the form of union security which is best suitable to their needs.

I would be against government saying to them, you must have this type of union security.

We must do better in the labor-management sphere in the defense area than we have been doing. I lay it on both—I cannot lay it on labor unions alone. There are actions of management which could be improved in this area.

One of my principal objectives as Secretary of Labor will be to improve this and to minimize the conflicts which exist in our defense establishment.

We cannot afford to curtail or hurt our national defense in this area.

We may have to revise our laws, I do not know, and in this sense, I would want to make a study. But more important than the law is the consensus, education, community of opinion, effort within existing laws to minimize these conflicts. If we are not able to do this through these devices, then it is inevitable that there will be laws which all fair-minded men will necessarily support.

New challenges

We now have a more urgent situation than in wartime. In wartime it is obvious that we can command and call upon the the whole population and get the necessary responses that we require.

War is a horrible thing, but in a sense there is no problem when a war is on to mobilize our entire resources and to get the cooperation that we need from all elements of our population.

Now, we are in a situation which is neither war nor peace, which we characterize as a cold war. This is the most difficult of all situations to be in, but at the same time we cannot meet this problem unless we are able to mobilize our people to this challenge.

I think we have to do more than we have done to alert all elements in our population that this situation which we are in, which may continue for a generation or several generations, makes it imperative that everyone recognize that they must play an important and responsible and active role in meeting the same challenges that exist in a period of total war—that is, asserting as the first consideration the national interest as against any separate or private interest.

What is happening in industrial life today is very analogous to what is happening in agricultural life. The labor force is decreasing, the white collar, technical and professional force is increasing.

A letter to ALPA from Secretary of Labor Goldberg

April 17, 1961

Mr. Clarence N. Sayen,
President
International Air Line Pilots
Association, AFL-CIO
55th Street and Cicero Avenue
Chicago 38, Illinois

Dear Mr. Sayen:

During my first weeks in office, one of the questions most frequently asked me by representatives of both labor and management was how I planned to administer the controversial Labor-Management Reporting and Disclosure Act.

Perhaps I might best answer this question by first briefly summarizing my personal views as to labor's ethical responsibilities. I have long felt that unions, by their very nature as organizations of trust to their members and the public, have a special responsibility to dedicate themselves to the highest ethical values. Therefore, I believe that union leaders who abide by only the letter of the reporting law are observing merely a minimum standard of conduct.

Few people know better than I that the vast majority of union officers are dedicated citizens. They are devoted to safeguarding the rights and advancing the interests of the members of their organizations. Yet we must frankly acknowledge that many reputations are being questioned in the public mind because of dishonest, corrupt, and unethical practices of a few who have betrayed their trust as labor leaders.

Let there be no question that we will deal with such corruption through vigorous enforcement of the law. At the same time, let me assure you that the law will be administered with reason and fairness. As in the past, the primary objective of the Department will be to achieve VOLUNTARY compliance. Such compliance has resulted in the overwhelming majority of cases to date because of the cooperation the Department has received from both labor and management. For example, we are required to check a sampling of the reports filed with the Department, and the records supporting those reports. The cooperation of affected parties — possibly because this work is conducted without publicity and with minimum disruption of the organization's activities — has been splendid. It is my hope that the future will see an even greater development of this general spirit.

Three years ago when legislation was first being considered to correct the abuses of the few, I said, "It is for the best interests of unions and their members that they must now live in the gold fish bowl of national curiosity. The gold fish bowl is not a bad symbol for responsible organizations in the American democratic society. To maintain the good will of fair minded employers, of public officials and of the mass of plain ordinary citizens, labor will constantly have to reaffirm that it has nothing to hide and much to proclaim."

My attitudes remain unchanged. As you know, a good portion of my time in recent years has been devoted to insuring ethical practice in the labor movement. That time was devoted to a cause in which I deeply believed. The objectives I sought then will be vigorously pursued in my new capacity.

I know I can count on your complete cooperation.

Yours sincerely,
Arthur J. Goldberg
Secretary of Labor

We need not despair about this. One of the great developments in life is to take off the backs of men some of the arduous labors they have had to experience. But we must take care of the people involved in the process.

I have great confidence in the people involved. I think that the people involved in production have the capacity and intelligence to take on new assignments. We must have more extensive programs of retraining and readjustment so that people can find useful employment.

What we need more than anything else—although we need relief now on unemployment compensation because it is running out and states are in trouble—are jobs and training and readjustment for all people who are willing and want to work.

It is imperative, if we are to retain our preeminence in the industrial world, if we are to afford jobs, if we are to meet the competitive forces which are operating worldwide today, that we replace outmoded equipment with new equipment.

It is true that a considerable part of our industrial machinery and plant and equipment needs modernization and need replacement.

I feel strongly, and have said publicly, that the labor movement must support this necessary progress for the benefit of the country, for the benefit of industry, for the benefit of labor.

We must have appropriate programs and policies so the great benefits that we derive from automation do not impose burdens in human terms upon people.

Automation problems

One of the challenges that we are now confronted with is to see to it that we automate completely, fully, and at the same time devise programs so that human values are preserved. We cannot go through the hardships and the misery that accompanied the first industrial revolution and I do not think there there is any difference in any segment of American life about this.

One of the big problems of this Administration is to help devise programs so that on the one hand we get the full potential of automation and on the other hand safeguard against hardships that happen to individuals, to families, when automation takes place.

I am confident that this can be done. I am not despairing that we must again repeat the horrible experience that took place when the first factories were introduced on the industrial scene.

I think we can have a greater economy, and I think with proper programs of labor and of management and government we can provide for a better standard of living for ourselves, we can provide for more efficient production which is the key to the better economy we all seek and we can provide for playing our necessary part in promoting the welfare of the other nations of the world which desperately need help and assistance from us.

We have to increase our productivity and I think it is entirely possible and feasible to do it and that the demands upon us domestically and in the world require it. I am confident that it can be done.

I feel strongly that obsolete practices, whether on the part of labor or management, can impede the orderly development of our country and can indeed restrain us from meeting the great problems that we have.

We are in unprecedented times; we are really in a war situation. We call it a cold war, but we need a general consciousness on the part of labor and management and all elements of our society that the traditional way and traditional practices no longer settle the grave problems that we have.

I think on the question of featherbedding, that no laboring man wants to featherbed. If the American character is manifest in any area it is manifest in the desire to do an honest day's work. That is a traditional aspect of our society. That relates to all aspects, all people, whether it is the man who works in a blue collar or in a white collar.

This is part of the same problem that is involved in automation. The people will insist upon traditional practices when they feel this is the only way of safeguarding their jobs and there are not adequate programs for seeing to it that they enjoy a reasonable amount of security.

Given programs that will give assurance to men who work for a living that their needs, their human needs, will be safeguarded and protected, I think whatever amount of featherbedding exists will diminish.

Foreign competition

Foreign competition is becoming a problem in the United States but I think in some areas it has been exaggerated. On the other hand, I am well aware that there are other areas where foreign competition is very pressing. It is necessary to deal with this problem in a constructive way. One of the important ways is to raise standards abroad.

I have participated in international conferences where this has been a great objective. I think we must strengthen our work at the International Labor Organization where this is one of the objectives. I think this is good for us and more important it is good for the countries of the world independent of us. We want to play our role in raising the wage standards of other countries in the world so that they can follow the path that we found was the right path in the United States, that domestic prosperity is bound up with the improvement in living standards.

One of my firm convictions is that the American people, through the press and the other agencies are entitled to the plain unadulterated facts dealing with important national issues.

We have a serious problem in unemployment; it is becoming more serious. It is my firm hope and pledge that regardless of the political consequences, whether it helps or hurts the Administration of which I am a part, we will fix dates for the release of all important data relating to the matters within my sphere of authority and we will not deviate from that, and we will give the American public all of the facts that bear on these issues.

That is a firm conviction of mine. I am sure former Secretary Mitchell shared it. I do not know what we will do about leaks in Washington. Those ideas are part of what we must live with. But within my power and within my authority we are going to give the facts and let the chips fall where they may.

IFALPA London Hdqr. moves to larger office

The International Federation of Air Line Pilots Associations (IFALPA) headquarters office in London has moved to larger quarters at 1, Hyde Park Place, London, W.2., England. The move was made from 6 Cavendish Square in order to obtain larger working space for the staff.

ALPA is a member of the federation and Mr. C. N. Sayen is president of the International Federation.

Operating Revenues and Expenses Of Thirty International Scheduled Airlines for 1951-1959

The figures contained in the statistical tables below cover the operations of the thirty international scheduled airlines for which suitable traffic and financial information covering the years of 1951 - 1959 has been reported to ICAO.

On the basis of tonne-kilometres performed during the nine-year period considered, this group of thirty airlines represents 76 per cent of the international scheduled services performed by the airlines of ICAO Contracting States.

Source: ICAO BULLETIN, Volume XV, No. 10, 30 December 1960

Description	1951	1952	1953	1954	1955	1956	1957	1958	1959
FINANCIAL DATA									
Operating revenues (U. S. $—thousands)									
Passenger	505 724	589 953	660 529	732 706	827 706	993 872	1 127 769	1 216 085	1 329 986
Cargo	80 239	90 119	95 144	110 090	120 048	138 928	155 727	163 555	181 509
Mail	99 411	104 462	106 742	108 850	115 161	124 063	127 119	133 356	135 418
Non-scheduled flights	27 377	21 707	21 653	27 091	29 497	36 064	36 568	45 010	53 402
Incidental revenues	18 218	26 200	37 713	34 240	31 556	54 222	58 237	57 772	64 295
Total operations	730 969	832 441	921 781	1 012 977	1 123 968	1 347 149	1 505 420	1 615 778	1 764 610
Operating expenses (U. S. $—thousands)									
Total	745 391	863 608	933 495	1 016 484	1 093 585	1 303 645	1 482 596	1 622 671	1 734 751
TRAFFIC									
Ton-km performed (thousands)									
Passenger	1 071 739	1 228 342	1 408 147	1 549 971	1 768 793	2 061 086	2 361 928	2 533 610	2 825 823
Cargo	289 955	317 131	327 457	362 090	406 823	480 262	537 758	557 123	647 492
Mail	109 636	120 104	132 326	157 837	188 025	200 552	211 509	228 303	244 663
Non-scheduled flights	67 202	54 683	64 869	73 484	88 971	117 432	132 831	153 449	224 130
Total operations	1 538 532	1 720 260	1 932 799	2 143 382	2 452 612	2 859 332	3 244 026	3 472 485	3 932 108
UNITS									
Operating revenues per t-km performed (U. S. cents)									
Passenger	47.2	48.0	46.9	47.3	46.8	48.2	47.7	48.0	47.1
Cargo	27.7	28.4	29.1	30.4	29.5	28.9	29.0	29.4	28.3
Mail	90.7	87.0	80.7	69.0	61.2	61.9	60.1	58.4	55.3
Non-scheduled flights	40.7	39.7	33.4	36.9	33.2	30.7	27.5	29.3	28.9
Total operations	47.5	48.4	47.7	47.3	45.8	47.1	46.4	46.5	44.8
Operating expenses per t-km performed (U. S. cents)									
Total	48.4	50.2	48.3	47.4	44.6	45.6	45.7	46.7	44.1

Only airlines whose international operations constitute a substantial portion of their total operations have been included but this does not necessarily mean that international operations constitute the majority of the total activities of any given airline. In cases where both traffic and financial statistics are reported to ICAO in such a way that it is possible to segregate the international operations, only the results of these international operations are shown.

* Where traffic, but not financial, statistics were available for international and domestic operations separately, total operations have been included or excluded depending on how much of the total operation was found to be international in character. In one case, where both traffic and financial statistics referred only to total operations, the entire operations were included because they were known to be largely international.

Financial statistics have been reported to ICAO in national currencies, which have been converted into United States dollars and gold francs at the exchange rates prevailing at the end of the financial year of the airline in question. In cases where an airline's financial year is not a calendar year, its annual statistics have been listed under the calendar year which contains the greatest part of the financial year. Tonnes are metric tonnes, i.e. 1 000 kg.

Some of the mail revenues of airlines registered in the United States of America are subject to retroactive adjustment by the Civil Aeronautics Board. In the present tabulation, all adjustments effected up to 14 June 1960 have been incorporated.

1951	1952	1953	1954	1955	1956	1957	1958	1959	Basis '51=100	1952	1953	1954	1955	1956	1957	1958	1959
PERCENTAGE DISTRIBUTION									**INDEX NUMBERS**								
Distribution of operating revenues (percentage)									Index of operating revenues								
69.2	70.9	71.7	72.3	73.6	73.8	74.9	75.2	75.4	100	117	131	145	164	197	223	240	263
11.0	10.8	10.3	10.9	10.7	10.3	10.3	10.1	10.3	100	112	119	137	150	173	194	204	226
13.6	12.5	11.6	10.7	10.3	9.2	8.5	8.3	7.7	100	105	107	110	116	125	128	134	136
3.7	2.6	2.3	2.7	2.6	2.7	2.4	2.8	3.0	100	79	79	99	108	132	134	164	195
2.5	3.2	4.1	3.4	2.8	4.0	3.9	3.6	3.6	100	144	207	188	173	298	320	317	353
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	114	126	139	154	184	206	221	241
									Index of operating expenses								
									100	116	125	136	147	175	199	218	233
Distribution of ton-km performed (percentage)									Index of ton-km performed								
[illegible]	71.4	72.9	72.3	72.1	72.1	72.8	73.0	71.8	100	115	131	145	165	192	220	236	264
[illegible]	18.4	16.9	16.9	16.6	16.8	16.6	16.0	16.3	100	109	113	125	140	166	185	192	222
[illegible]	7.0	6.8	7.4	7.7	7.0	6.5	6.6	6.2	100	110	121	144	171	183	193	208	223
[illegible]	3.2	3.4	3.4	3.6	4.1	4.1	4.4	5.6	100	81	97	109	132	175	198	228	331
[illegible]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	112	126	139	159	186	211	226	256
UNITS IN GOLD FRANCS																	
Operating revenues per t-km performed (g. fr.)									Index of operating revenues per t-km performed								
[illegible]	1.47	1.44	1.45	1.43	1.48	1.46	1.47	1.44	100	102	99	100	99	102	101	102	100
[illegible]	0.87	0.89	0.93	0.90	0.88	0.89	0.90	0.87	100	103	105	110	107	104	105	106	102
[illegible]	2.66	2.47	2.11	1.87	1.89	1.84	1.79	1.69	100	96	89	76	67	68	66	64	61
[illegible]	1.22	1.02	1.13	1.02	0.94	0.84	0.90	0.88	100	98	82	91	82	75	68	72	71
[illegible]	1.48	1.46	1.45	1.40	1.44	1.42	1.42	1.37	100	102	100	100	96	99	98	98	94
Operating revenues per t-km performed (g. fr.)									Index of operating revenues per t-km performed								
[illegible]	1.54	1.48	1.45	1.37	1.40	1.40	1.43	1.35	100	104	100	98	92	94	95	96	91

from U. S. News & World Report, April 10, 1961

MAKING IT SAFER TO FLY---

THE NEXT STEPS

Interview With NAJEEB E. HALABY
Federal Aviation Administrator

What actually is being done to improve safety in the air? Are important changes in airports and control systems just ahead?

Should airlines be more candid with passengers about potential troubles on a flight? As skies get more crowded, will risks increase?

The new administrator of the Federal Aviation Agency, Najeeb E. Halaby, answers these and other questions of interest to air travelers in this interview with "U. S. News & World Report."

Mr. Halaby believes the airways have suffered from "18 years of neglect." He tells how he hopes to improve them, making flying safer and more convenient for the public in the future.

FAA Photograph

Q. Mr. Halaby, is this country's control system in the air adequate to assure safety?

A. As the President said when he appointed me, the future is full of perils and prospects for aviation. Faster speeds, more complicated aircraft, more demand on pilots and controllers, more variety—helicopters, supersonic transports, and so on—mean that, unless we have a very good air-traffic-control system, the risks will increase.

Q. Don't we have such a system today?

A. The way we get as much safety as we have today is that we restrict and slow down air traffic, so the facilities can accommodate the traffic.

For 18 out of the last 20 years, we neglected aviation facilities so badly that, to assure safety, we have to make these restrictions.

One of my goals is to have, several years from now, a system that will enable all those who fly to fly in the right place safely, with less separation and with greater economy.

Meanwhile, we can't let air safety decline. We can't allow a preventable accident. We have to do whatever is necessary with whatever we have to prevent accidents. But no man can assure you there won't be another accident, and no man can prove that the risks will not increase.

Q. Is the density of air traffic around our major cities becoming too great for controls now available?

A. Well, obviously, the density is so great that you have to keep airplanes on the ground while they wait their turn to get into the air-traffic-control system. So you see at La Guardia Airport, up at New York, maybe 15 airplanes lined up on a bad day with propellers ticking over, waiting to take off.

Q. Is this a problem at only three or four big airports around the country?

A. No, I think it's worse than that. I think it's a problem, let's say, in Los Angeles, Chicago, Detroit, Cleveland, Washington, New York, Boston, Atlanta, Miami—it's in that number of airports and maybe more.

Q. Can a person flying into one of these areas in an airliner feel perfectly safe?

A. I don't know where a human being is "perfectly safe." One of the most dangerous places on the planet, as I understand it, is standing in a bathtub. If you slip, a bathtub is very unyielding.

I don't feel particularly safe crossing Fifth Avenue at 57th Street in New York, or on the Los Angeles Freeway. Where is man safe? I say that I feel safe enough in the air to fly constantly myself and have my wife and child on fly.

Q. If you and Mrs. Halaby are making the same trip, do you take separate airplanes?

A. We thought about that once, but

even though we have three children, we do not feel that flying is that dangerous. Would you take two cars to go on the Freeway? Would you cross the street at separate corners? I think not.

I think it's my job to try to get aviation system advanced enough so that it's not only safe, but it's efficient, economical, convenient and comfortable.

We've launched a task force which we call "Project Horizon." Its purpose is to try to establish where we want to be in this aviation system by 1970. Complementary to it, we have a distinguished scientist under the President's Science Advisory Committee and a second task force, "Project Beacon," looking at how we can research and develop our air-traffic-control system up to the very best standards, as quickly as possible. One objective will be to get double duty out of some of the defense dollars that have been spent on electronics.

We have this whole matter of pushing forward with the small airplane, with the helicopter and with the freighter. One of the great potentialities here is air freight, and the award of the contract for the military air freighter to Lockheed Aircraft Corporation will push this forward, because that airplane is designed to meet both military and civilian requirements.

Q. Are the nation's airports keeping pace with the jet age?

A. We have quite a few airports under construction right now. In New York, Idlewild is pretty nearly completed and La Guardia is in the midst of a complete modernization. Los Angeles International Airport will dedicate a new terminal building in late June, and it will be most modern. Midway and O'Hare in Chicago have recently been brought up to date.

Now, there are two features about airports you have to think about:

One is safety—the runways, the lighting, the taxiways, and all of the features that contribute to flying safety.

Then, there are what you might call the convenience and comfort features. Those, generally, are inside the terminal. I think the Government ought to concentrate on getting the passengers there safely and I think the communities ought to keep them warm and dry and comfortable.

Q. Along with improved airports, what is needed to improve air-traffic-control and make it possible to have more planes flying at the same time, with safety?

A. These are the directions in which we're working:

First is to prepare a national system rather than improvise new equipment on top of old equipment, which has been the tendency in the past. That's why we have this "scientific engineering task force."

The second is to understand where the growth in traffic is going to be, so we can concentrate our effort on those danger areas. We have lots of estimates and projections, and they look pretty sound.

The third is to develop devices, such as three-dimensional radar, that will give us a much more precise location of airplane A in relation to airplane B, because we've got to keep them separated.

Q. What do you mean by three-dimensional radar?

A. Three-dimensional radar will provide altitude information to go with the distance and bearing (direction) data which is available from existing radar. When we get this installed, we'll have another tool for finding out just where an object in space is. But this won't be the end, because radars are subject to rain, snow and all kinds of precipitation. This is just another piece of the system.

A fourth direction in which we must move is to process the data we obtain from the radar and the communications we get from the pilot. We will need automatic data-processing equipment.

A fifth problem is that it takes a lot of time to say something—the human voice is not the quickest way to communicate.

Q. What is the quickest way?

A. There are various forms of telemetered and automatic data transmission. You've perhaps seen these new printers that will print out in seconds a whole page. So, we will have automatic ground-to-air communications that will print out on a little printer in the cockpit, perhaps. The pilot will just punch a button and will say, for example, "Clearance for landing," and it will come back from the ground, "Runway 31," on a printer, or on a little TV screen.

Another direction in which we must work is a better airport system, so that perhaps small planes could land at Mitchel Field and not need to go into Idlewild. That would sort out the low and slow aircraft from the high and fast aircraft without inconveniencing either.

Q. Is there equipment now available, but not in use, that could improve air safety?

A. I think there is. The problem is to find and integrate it into the present system, which has been improvised over the years.

Now, when you come to the end of the mecahnical improvements, you still have the human mind as the only device that yet knows how to *decide* things. The mechanical brains can compute and calculate and so on, but you have to have somebody who makes a judgment.

The recruitment, the training, and the incentives necessary to build an elite corps of air-traffic controllers is a major feature in increasing the capacity and efficiency and safety of this system.

Q. Do you intend to continue the ruling for mandatory retirement of air line pilots at age 60?

A. That is one of my predecessor's rulings that I am reviewing, and I haven't reached a conclusion whether to confirm it or change it.

Some of the foreign air carriers, I'm told, require retirement at 55. We have not had a great deal of experience with pilots after they reach 55 or 60, because we haven't had many pilots who were that old. So the medical evidence, the statistical evidence, is rather thin.

There's the element of public confidence. Does the public want to fly in a large high-speed airplane with an older man? And then there are the privileges and rights of the pilots themselves who have devoted their lives to bringing their proficiency to a peak. Is is fair to say to a man on his 60th birthday, who may be the best pilot in the fleet: "You may not fly the airlines any longer?"

Now this ruling, by the way, doesn't banish the man from flying. It says he may not fly as pilot in command of an air transport. He may go and get another commercial-pilot job which may be less demanding.

In the end, I have to decide whether or not this ruling is right. My predecessor's ruling has been sustained in both the federal district court and the federal circuit court. If I were to change the ruling, my decision would be subject to review by a competent court.

Q. Are private pilots and business pilots going to be increasingly restricted as our air space becomes more crowded?

A. Projections show that the greatest increase in numbers of pilots will be in the field of general aviation, which is the private and business flying group.

The military operations are beginning to flatten out and taper off a little bit, as missiles come in. The air line operations are still rising, but at a

slower rate. But general aviation is still rising at a fairly rapid rate.

Until we have an air-traffic-control system that has adequate capacity, there will be restrictions. And, if this increase in traffic continues to outpace the system, there probably will be more restrictions before there are less restrictions. But the goal must be to have the least restrictions and the most safety and efficiency.

Now, we've talked about a lot of the problems. I'd like to spend one minute on the prospects because there are terrific opportunities for aviation in the '60s. We're ahead of the rest of the world in aviation at the present time. We can only stay ahead by going forward with developments. There is a "new frontier" in the air. There's just no question about it.

Here are some of the developments that we can have:

We can have a system that's both safe and full capacity. We can get the cost of flying down—

Q. To the passengers?

A. To the passengers.

We can get more modern jets. Each of these jets will have a growth factor in it. We can move into the supersonic transport toward the end of the '60s, which will enable us to fly from Los Angeles to New York in an hour and 45 minutes, and from New York to London in two hours. We can achieve that, if we keep moving. And we are asking Congress for 12 million dollars to start an intensive effort by industry to further study the technical problems.

We can have a military-civil air freighter—and we will—which will provide much more rapid and relatively economical air freight.

We can have an interurban air bus and interurban air truck. We can improve the personal aircraft by making it more nearly a safe, all-weather airplane.

And, in the '70s, we're going to see space travel. All of these things are going to unfold for us. The immediate problem is to survive this crisis brought on by neglect of our facilities. Meanwhile, to provide safety, we'll have to slow things down while planning ahead for the great growth of aviation.

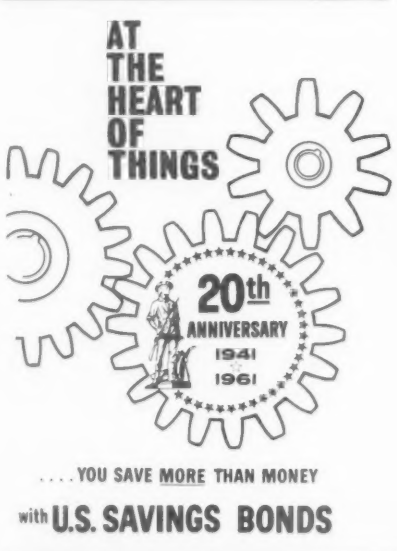
Q. Can anything be done to reduce the amount of time you spend on the ground, getting on and off planes, getting your baggage?

A. That is an economic matter, and I think it has to be left in the hands of private enterprise. In the Soviet Union, where you have Aeroflot, a socialized air line, the Government runs the show all the way through. In this country, we choose which air line we want to use on the basis of how safe it will be, how economical it will be, and how convenient.

I think the air lines can, and will, provide a more convenient and more dependable service. I think, too, that they ought to provide a more candid service.

Q. What do you mean by that?

A. I believe they ought to give us passengers available information on which we can base a judgment on whether or not we'll fly and, if so, on what flight and under what circumstances.



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Q. Should the passenger be told what kind of weather he'll be flying into?

A. Yes. The man about to buy a ticket ought to be able to get information about weather, and delay, and air-traffic control, and other potential problems in the flight. Then he can go to the airport with a greater sense of confidence and assurance that he's going to do what he planned to do.

Q. When you give federal aid to a city to build an airport, what does that money go to build?

A. In the past, there have been various policies. In some areas, there has been aid only to build runways themselves and navigation facilities. At other times, federal aid has extended to terminals. My intention is to concentrate the relatively small amount of airport aid upon safety features—runways, turnoffs, taxiways and airport lighting. Aid to terminal buildings would be an exceptional rather than a normal occurrence.

Q. Should new airports be located farther from cities for safety and noise reasons?

A. The new Dulles International Airport is quite a distance from downtown Washington, and Friendship International near Baltimore is an even greater distance from downtown Washington. Helicopter service is under consideration to make it possible to take a twin-engine helicopter from downtown Washington to Dulles or to Friendship. Right now, you can use helicopters in New York—you can fly from Wall Street to La Guardia or Idlewild or Newark. Also in Chicago and Los Angeles. This offers one way of solving the interairport problem and permits you to disperse a field.

But, only a few years ago, Idlewild was well dispersed, and now it's located in the center of a community—and a rather irritated community, because the frequency of jet flights is sufficient to irritate a large number of very fine people.

Q. In addition to putting the airport farther from the city, should there be zoning to keep people from moving in on the airport after it's built?

A. I think that, definitely, long-range regional planning is necessary here, because the technical capabilities for reducing the noise output from ever-more-powerful engines are not great. Los Angeles area officials recently launched a far-sighted regional study of this problem.

Now, our engine manufacturers are working on noise suppressors. When you think of it, standing at the corner when a fully loaded bus accelerates at full power is not the quietest place to be. We've learned to live with bus and truck and train noises.

Of course, you can change flight patterns and require planes to climb out faster and glide in steeper. But this is not good because you begin to compromise safety, particularly in bad weather.

Another way to get at this noise problem is in the construction of offices and homes. As air conditioning becomes more economical, you'll have more window-closed living, perhaps, and the noise will be less irritating. But the long-term solution is for regional planning that gives you a spacing and a placing of airports, that provides zoning for the take-off and landing approaches to the airport.

And, finally, there's the good old American custom of "Let the buyer beware," of not buying where, within a short time, there is going to be an

(Continued on Page 22)

With the Flight Attendants

Stewardesses work with 727 evaluation committee

Boeing Company Photo

STEWARDESSES Jo Ann Lacey of West Coast Air Lines and Sally Gibson (right) of United Air Lines were part of the ALPA, 727 Boeing evaluation committee. With them is Henry Lacy of Boeing.

One of the current projects being conducted by the ALPA Steward and Stewardess Division jointly with the pilot division is the evaluation of the new Boeing 727 from the point of view of cabin attendants.

Stewardess Sally Gibson of Central Air Lines and Jo Ann Lacey of West Coast Air Lines spent one full day viewing the cabin mock-up and discussing cabin safety and en route equipment with Boeing engineers.

The study was made on the wood and paper mock-up of the new aircraft at a stage when changes could be made. It will be two years before the 727 will be available to air lines.

In the past, pilot evaluation groups from ALPA have made suggestions for new aircraft which were adopted in the design and now they are assisting cabin attendants to achieve the same goal.

ALPA chalks up eleven consecutive victories

The Air Line Pilots Association (AFL-CIO has chalked up its eleventh victory in as many elections to permit flight attendance to signify which organization they desire to represent them.

Capital victory

The recent series of election victories began when the flight attendants of Capital Airlines cast 98 per cent of their votes naming the Steward and Stewardess Division of ALPA as their collective bargaining agent. This was the seventh victory for ALPA.

Votes in a secret-ballot election conducted by the National Mediation Board under provisions of the Railway Labor Act and counted in Washington, D. C., on May 29, showed ALPA receiving 315 of the valid votes cast to only 5 for the Air Line Stewards and Stewardesses Association. Flight attendants on United, with whom Capital is in the process of merging, have already voted to be represented by ALPA.

Piedmont votes for ALPA

Flight attendants of Piedmont Airlines have voted 42 to 1 to be represented by the Air Line Steward and Stewardess Division of the Air Line Pilots Association in a secret ballot election conducted under provisions of the Railway Labor Act by the National Mediation Board, ballots which were counted in Washington, D. C., June 6, showed.

It was the eighth victory for the ALPA in as many elections.

The only other organization on the ballot, the Air Line Stewards and Stewardesses Association, received but one vote of the 43 valid votes cast.

The Piedmont election is one of a series the ALPA has requested to permit individual flight attendants to designate whom they desired as their collective bargaining representative.

Continental, Ozark results

The most recent elections, held in the middle of June, added the tenth and eleventh victories held under the auspices of the NMB.

When the ballots were counted on the tenth election, flight attendants of Continental Air Lines voted 116 to 41 for ALPA. Ballots were counted in Chicago.

The eleventh victory came when Ozark flight attendants voted 45 to 22 for ALPA.

Future elections pending are on National, Aloha, Allegheny, Lake Central, and Hawaiian air lines.

ELECTION BOX SCORE

	Air Line	ALPA	Other
(1)	Braniff Airways	214	8
(2)	United Air Lines	891	183
(3)	Pacific Northern	19	13
(4)	West Coast	53	0
(5)	Alaska Airlines	22	2
(6)	Mohawk	51	0
(7)	Capital Airlines	315	5
(8)	Piedmont Airlines	43	1
(9)	North Central	98	7
(10)	Continental	116	41
(11)	Ozark Air Lines	45	22
(12)	Overseas National*	36	0

*Elected to transfer from ALEA to Steward and Stewardess Division, ALPA.

Capital Stewardesses get their United Wings

United Air Lines Photo

UAL PRESIDENT W. A. Patterson welcomes Capital Airlines stewardess Florence Schroeder (right) as Capital is officially merged into United on June 1. UAL stewardess Peggy Holloway looks on as Patterson pins United Wings on Miss Schroeder.

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A PERSONAL . . .

(Continued from Page 3)

fornia Auto Association — Special death benefit policies.

18. *Workmen's Compensation—Death Benefits*

Widow with no children . . . $15,000
Widow with one or more minor children 20,500
Burial expense 400

19. *Veterans Administration*

a) GI Insurance
b) Widow and/orphans pensions
c) Educational allowance for children
d) Burial expense
e) Burial in National Cemeteries

NOTE: *Benefits change due to acts of Congress—check with the nearest office of the Veterans Administration for current rulings.*

20. *Social Security*

a) Survivors payments—

1) Certain members of your family can get monthly payments in the event of your death. Example: a widow and two children—$254 per month (minor children).

2) In addition a lump sum death payment can be made to your widow. It cannot exceed $255.

NOTE: *Benefits change due to acts of Congress—check with the nearest Social Security Administration office listed in your phone book under U. S. Government, Department of Health, Education and Welfare.*

21. *Banks or Savings and Loan Companies*

Check local banks for accounts, any unknown trust funds. Local bank manager will be of inestimable assistance to you at this time.

22. *Brokerage Office*

23. *Safe Deposit Boxes*

NOTE: *Remember that all safe deposit boxes will be sealed by the bank following death of the renter until a date is agreed upon to be reopened in the presence of the Internal Revenue Department representative. This applies even if husband and wife are co-renters of deposit box.*

24. *Bank as Executor of Estate*

Notify bank if bank has been named executor or co-executor of estate.

25. *Attorney*

Attorney should be contacted. Will may have been placed with decedent's attorney for safe keeping.

26. *Miscellaneous*

Thus, by checking your personal affairs against this guide, it will be possible for you to have a clear idea of where you stand. However, it must be stressed that the check list given here is only a *model*. While the information given here is correct, it is in an abbreviated form and subject to change. When preparing a checklist for yourself, check each item against current source material.

MAKING IT SAFER . . .

(Continued from Page 20)

airport. If he doesn't want the noise, he should have a little foresight and locate elsewhere.

Q. Will this process of improving air safety involve more airports and improvements on existing airports?

A. President Eisenhower and my predecessor proposed that there be a steady declining program of federal aid to airports, and that the amount for the fiscal year starting next July 1 be reduced to 40 million dollars. Now, this was, I believe, a budgetary reduction. It was not a conviction that this was the best way to get the best aviation system.

I've recommended that we increase and expand our system of airport aid from the 40 million dollars recommended in the Eisenhower budget to 75 million for the fiscal year of 1962.

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HUMAN ENGINEERING

(Continued from Page 6)

"time to rotate" in a "go-no-go" fashion.

Man's limitations result in premature or late rotation greatly affect take-off performance and climb path of *all* transport aircraft of today. Advancements in jet transports of the future indicate an *absolute necessity* of such electronic fail-safe indicating devices.

Man will be up to the task if electronic devices and advanced instrument design and navigational facilities are all added.

The pilots of today's transports must contemplate a maze of instruments which appear to be constantly diminishing in size and calibrations. Economy of space has been achieved by reducing gauge sizes. Ironically, certification tests of transport aircraft are made with specially adapted instruments such as 7-inch airspeed dials. When approved, the aircraft goes into service with standard 2½ inch dials and ¼ inch arc represents 20 knots airspeed.

Today's modern transports have need for accurate outside air temperature readings within 1 to 2 degrees to facilitate high level flight, requirements and a knowledge of icing, turbulence, jetstream movements and static discharge potentials which are all a function of temperature. The gauges are calibrated with ⅛ inch representing 10 degrees centrigrade, and correction for airspeed friction must be computed as they are not direct readings.

Man's limitations are not restricted to visual interpretation and slow reaction times alone. Verbal interpretations involving semantic confusion enters the picture on occasion even among well-drilled cockpit crews. Take this example of the captain's command to the engineer on take-off. "Take-off power!" was called out to the engineer to *set* take-off power. Result: the engineer "took off" the power causing an aborted take-off.

Comparable was the command for the engineer to "Feather two!" The engineer queried, "Which two?" The confusion which leads to the feathering of the wrong engines is still with us. Thus, even the area of semantics and communication must be considered as variables concerning flight safety.

In conclusion we must view the aeronautical engineer's task as a *complex* of design considerations. The machine must be so designed that it withstands the expected rigors and stress of flight and the systems and controls and the cockpit designed to be compatible with man the operator.

Quoting Benny Howard: "Our failure to so design the cockpit is responsible for 15 times as many crashes as result from structural failure; yet there is very little comparison in the engineering dignity we give the two subjects."

---

[1] Hoover, George Commander. *Aviation Age*, June, 1958.

[2] Fogel, L. J. "Better Cockpit Display." *Aviation Age*. July, 1958.

[3] Gunn, W. H. "Psychological Influences of visual Perception in Flight." April, 1958.

[4] Howard, Ben O. "Pilot Error and Aircraft Design." *American Aviation*. March, 1953.

THE PREVENTION . . .

(Continued from Page 11)

a small compression ratio and the compressor delivery temperature too low to be of practical use for anti-icing.

Sometimes design considerations preclude the fitting of a manifold to the compressor casing large enough to carry sufficient air for surface heating as well as for other services; but, most important of all, the total bleeds required may be too large for the compressor. Too great an intermittent bleed quantity, tapped from the compressor, could cause mis-matching between the compressor and turbine and unless the bleed control is linked in some way to the fuel control system, there is a risk of the engine surging.

"Run-back" ice

A most unpredictable, and most serious, icing hazard is caused by so-called "run-back" ice. This occurs on some unheated portions of an engine and is caused by supercooled water which has frozen, melted and then frozen again beyond the heated surfaces. Run-back ice is particularly serious in the intake tunnel between the cowl lip and the actual engine air-intake. In some installations this tunnel can be 17 feet in length and it is impossible to heat the whole of such an area to prevent ice forming. The only complete solution is to keep the cowl lip dry and entirely free from ice, but this would necessitate high-intensity heating of some 40 watts/sq in. To install such a system would only be possible in very exceptional circumstances and so a compromise solution is employed which offers two alternatives.

Both alternatives rely upon an engine's ability to ingest pieces of ice. The first involves low-intensity heating over the entire tunnel area. As the ice builds up so the layers touching the wall become insulated by the total thickness of the ice and are protected from the cold air flowing down the tunnel. These inside layers then become warmed from the walls and, ultimately, the combined effect of heating and aerodynamic forces from the air stream cause the ice to break away.

The other method calls for a cyclic heating system on the cowl lip which will permit ice to form and then break away as with the previous method. If ice forms and is shed then no supercooled water should remain to cause run back.

Careful design of the heating system is essential in both cases to ensure that the pieces of ice are not large enough to damage the engine.

Safety and reliability

The two principles which take precedence over all other considerations in aero-engine design are safety and reliability. Guarding against ice, and the effects of ice, are problems which must be overcome before any engine can meet these requirements and constant development is necessary to ensure that the safest and most reliable anti-icing system is fitted to all engines.

At Bristol Siddeley many man-hours have been spent in providing safe, comprehensive anti-icing systems and the work still goes on. It is not anticipated that any startlingly new advances will be made in future, as by the evaluation of a large number of alternative systems the present line of development seems to be the most rewarding. Most of the work in future will probably be concerned with increasing the effectiveness of current systems and at the same time improving their efficiency, both in reducing the amount of heat wastage and the complexity of the ducting. Each new engine has its own problems and as some designs are more vulnerable to icing than others it would seem unlikely, therefore, that much respite will be afforded to the anti-icing engineers.

With the high Mach number aircraft now flying or projected, icing at their cruising speeds will no longer be a hazard, although it may still be present during other flight conditions. The air passing over forward facing surfaces will provide heat which may itself be an embarrassment. At Mach 2, for example, the air stagnation temperature at the intake is about 120°C, at Mach 3 it is 330°C and at Mach 4.5 it is as high as 780°C. The problem will then become one of refrigeration!

AIRMEN'S PLEDGE

Oh' Silvery Eagles, who do labour with love,
Delicious airships, that roam high and fast above;
Up on levels fine, enjoying deep halcyonic mood,
We do integrate them, with clean-cut gratitude.

When we may no more, crew our cozy, powerful plane,
We just hope to keep, somewhat cheerful, all the same;
But in clear blue sky—inside clouds or through pure air,
Does the true bird's soul, almost always, wish to fare.

We ask for space free, and life smart, and aircrafts sound,
For our hearts indeed, are air-rovers, all-around;
So that ever after, we no more, bear such wings,
May our spirits float along, with light, in fair winds.

CAPT. A. W. HOFFMANN
Rio, 1958.
Panair Do Brasil S/A
Praca Marechal Ancora
Rio de Janeiro, Brasil

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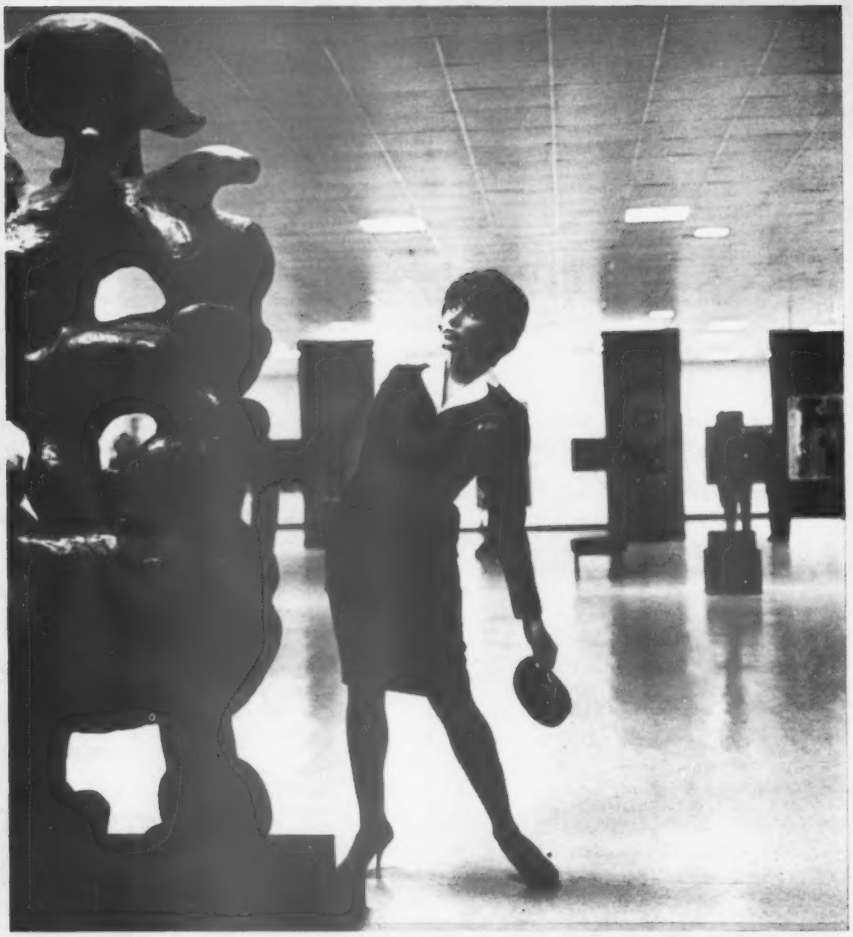

Chicago Stewardess Corina Brown at a Chicago Museum as photographed by EAL Pilot Frank Garner, Professional Photographer. We salute the pilots of Eastern Air Lines who will have been insured under our plan for 10 years on August 1st — with no increase in rate. Eastern was our first pilot group.

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